

STUDIES ON FOOD AND FEEDING HABITS, FOOD PREFERENCE AND FEEDING MECHANISM IN THE MILLIPEDE *JONESPELTIS SPLENDIDUS* VERHOEFF IN CAPTIVITY

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The adults of *J. splendidus* Verhoeff when offered leaf litter in different stages of decay, accepted only the litter in its advanced stage of decay. They showed preference to a few species of litter from the ten different species of plants offered, specifically the litters of *Artocarpus*, *Terminalia* and *Macaranga*. The litter of plants tested include *Anacardium* and *Eucalyptus* which contains well known secondary plant substances. When sugar and polyphenol content of fresh litter was estimated, it was found that the preferred litter was having comparatively a very low polyphenol content and high percentage of sugar. The morphology of mouth parts and the feeding mechanism of the animal were also noted.

INTRODUCTION

Millipedes form a component of the detritivore food chain in terrestrial ecosystem and are therefore important ecologically. *Jonespeltis splendidus*, the common flat back millipede is mainly a feeder of leaf litter which is also evidenced by the microscopic examination of the gut contents. Activities of *J. splendidus* in soils with different types of organic matter and also their role in humification of soils were reported by Bano & Krishnamoorthy (1981a, b). The present report is based on the studies conducted in captivity to find out the feeding behaviour and food preference in *J. splendidus*, considering feeding as a part of their ecology and its role in soil humification. Behavioral studies in the laboratory may help in assessing it in nature. Barlow (1957) and Drift (1965) have shown that millipedes exhibit food preference and are highly selective. Sakwa (1974) suggested a chemical basis for acceptance of food by millipedes.

MATERIAL AND METHODS

The adult *J. splendidus* of both sexes collected from the Zoological Garden, Trivandrum were used for the present study. They were brought to laboratory and reared in earthen pots containing moist soil and decayed litter. About fifty animals could be kept at a time. The unhealthy animals in the stock

were replaced regularly and those thrived well were selected. During the course of our study in 1986-87, the animals occurred in nature during the months of June to January. So the animals were collected during this period from the field. The mouth parts of the animal were examined first and then feeding behaviour noted. Mouth parts were teased out under the dissection microscope, cleared in lactic acid, mounted in glycerine on slides and studied under the microscope. Drawings were made by using camera lucida. The feeding behaviour was noted by placing the animals in glass container and offering them different types of leaf litter in different stages of decay. The movements of mandibles, gnathochilarium, antennae etc. were observed.

Food preference experiments were conducted in plastic containers of 10 cms height and 10 cms diameter which were not provided with any base material. The litter of plants tested were *Artocarpus integrifolia*, *Anacardium occidentale*, *Eucalyptus lanceolatus*, *Macaranga peltata*, *Terminalia catappa*, *Mangifera indica*, *Achras sapota*, *Hopea whitiana*, *Lagerstroemia flos-reginae* and *Polyalthia longifolia*, collected from the University Campus, Kariavattom.

In the first set of experiments (Table I), three stages of leaf litter (freshly fallen, partly decayed and in an advanced stage of decay) of one plant species were collected from the field, cut into equal areas from them and moistened by putting them in water for two days. The moistened litters were then placed in experimental containers in small bits at equal distances, and one animal was introduced in each container. Wet cotton was placed on each bit so as to maintain the moisture content. Five males and five females specimens were used in each set of experiment. All the animals selected for study were subjected to starvation for fortyeight hours prior to the commencement of the experiment to standardise their physiological conditions. Average consumption per day by five males and five females on each leaf bit was measured upto the seventh day, separately by placing the fed leaf bits on graph paper of equal area and counting the columns already eaten. This experiment was performed in the same manner with all the ten species of leaf litter separately.

The second set of experiments (Table II) was intended to assess the preference shown by the animal towards different species of plant litter. For this, decayed leaf from all the ten plants were offered together in equal amounts, at a distance of 2.5 cms apart in a container having a diameter of 20 cms and one animal was introduced. Consumption of different species of leaf litter was recorded and compared by noting the volume consumed within a week. Area of each leaf eaten was measured as above and the thickness of leaf of all species was noted. This experiment was repeated five times to arrive at average consumption per species of plant litter.

The influence of attractant (sugar) and deterrent (polyphenol) chemicals

Table I. Showing average per day consumption of each type of litter in mm².

Days	Type of litter	<i>Terminalia</i>		<i>Artocarpus</i>		<i>Macaranga</i>		<i>Anacardium</i>	
		F	M	F	M	F	M	F	M
1st	a	-	-	-	-	-	-	-	-
	b	1	80	-	-	5	7	-	-
	c	343	139	71	34	85	84	21	7
2nd	a	4	-	-	-	-	-	-	-
	b	-	18	32	3	3	5	-	-
	c	115	68	37	20	36	34	4	3
3rd	a	2	-	-	-	-	-	-	-
	b	7	15	17	4	5	5	-	-
	c	142	64	82	27	33	34	14	6
4th	a	2	-	-	-	-	-	-	-
	b	2	16	42	12	2	14	-	-
	c	65	26	133	47	12	43	2	5
5th	a	3	-	1	-	-	-	-	-
	b	4	12	54	4	12	26	-	-
	c	88	27	95	14	16	40	8	13
6th	a	2	-	2	-	-	-	-	-
	b	3	-	77	4	27	12	-	-
	c	22	10	38	78	49	80	10	13
7th	a	4	4	4	-	-	-	-	-
	b	11	-	25	10	34	47	-	-
	c	25	8	9	12	73	37	-	-

F - Female

M - Male

- Indicates no feeding

a - fresh litter

b - partly decayed litter

c - advanced stage of decayed litter

initial amount of leaf bit gives = 900 mm² each.

<i>Achras</i>		<i>Polyalthia</i>		<i>Eucalyptus</i>		<i>Mangifera</i>		<i>Hopea</i>		<i>Legerstroemia</i>	
F	M	F	M	F	M	F	M	F /	M	F	M
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
7	21	7	6	11	-	2	1	2	3	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
12	22	8	1	1	-	2	1	1	1	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
11	8	10	1	2	-	1	2	-	3	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
11	4	2	2	2	-	1	1	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
8	8	3	2	4	-	4	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
9	4	2	2	2	-	2	1	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
6	7	3	11	1	-	1	1	-	-	-	-

on the feeding preference of millipedes to litter (Sakwa, 1974) was determined by estimating the sugar and polyphenol contents in the fresh litter of two preferred and two unpreferred plants, following the methods of King & Heath (1967) and Swain & Hillis (1959).

RESULTS AND DISCUSSION

The animal was found feeding only the moistened litter in its third degree of decay. When only one type of preferred litter was introduced the animal sense the food with the antennal tips, begin to feed on it. After sometime the animal again wanders in the container perhaps in search of other types of food and not finding anything else, returns to feed on the same bit and this process is repeated.

In the experiment where there is a variety of food stuffs provided, they first of all sense individually every item of the food and then begin to concentrate on presumably the preferred ones. After sometime, search for another bits, begins eat it, if not preferred, then to another and so on. These activities showed that *J. splendidus* need a variety of food stuffs.

Table I shows the result of laboratory feeding tests in which different

Table II. Showing the consumption within a week when ten species of decayed leaf litter were offered together (selective feeding).

Type of decayed litter	Area eaten within 7 days (mm ²)	Thickness of leaf (mm)	Volume of material consumed (mm ³) : Area x thickness
<i>Terminalia</i>	430	0.16	68.80
<i>Macaranga</i>	463	0.13	60.19
<i>Artocarpus</i>	160	0.31	49.60
<i>Achras</i>	22	0.22	4.84
<i>Anacardium</i>	10	0.23	2.30
<i>Mangifera</i>	6	0.33	1.98
<i>Eucalyptus</i>	6	0.31	1.86
<i>Polyalthia</i>	6	0.17	1.02
<i>Hopea</i>	4	0.23	0.92
<i>Lagerstroemia</i>	2	0.29	0.58

stages of decayed leaf litter of ten different plant species were offered separately. Of the three stages of litter in all plant species tested, the preference for the litter in its advance stage of decay was only shown from the first day, indicating the palatability of the animal. However, there is a variability in the amount of consumption of different species of plant. *Artocarpus*, *Terminalia* and *Macaranga* are observed to be more preferred food ones, as compared to the other species. In these three cases, the partly decayed litter were also found to be consumed. It testifies to the less deterrent nature of the leaf litter. Compared to them it can be said that the amount of consumption of *Anacardium*, *Eucalyptus*, *Hopea*, *Lagerstroemia*, *Polyalthia*, *Mangifera* and *Achras* in all stages of decay is at a very low ebb. From the foregoing observations it is interpreted that their palatability increases with stage of decay of litter which agrees well with the findings of Kheirallah (1966), Schmidt (1952) and Gere (1956) in other species of millipedes.

Table II shows the result of preferential feeding experiments carried out by offering ten different species of litter in an advanced stage of decay, together in one container. Of the ten plant species selected, feeding was initiated in all, but more liking was shown again for *Artocarpus integrifolia*, *Terminalia catappa* and *Macaranga peltata* and less for *Achras*, *Anacardium* or other species. In *Mangifera*, *Polyalthia*, *Eucalyptus*, *Hopea* and *Lagerstroemia* only a few mm² of bit was damaged from the sides. The amount consumed within a week showed a definite preference towards decayed litter of *Terminalia*, *Artocarpus* and *Macaranga* testifying to their food preference as in first set of experiments.

Table III shows the amount of sugar and polyphenol in the fresh litter of two preferred and two unpreferred plants. The polyphenol content (deterrent chemical) was found to be very less in *Artocarpus* and *Terminalia* compared to *Anacardium*. In *Artocarpus* sugar content (phagostimulant) is high compared to polyphenol. *Terminalia* although sugar and polyphenol content in somewhat equal in concentration, the phenols may be less toxic sometimes and so in the above two

Table III. Showing sugar and polyphenol content in 100 mg of each fresh litter.

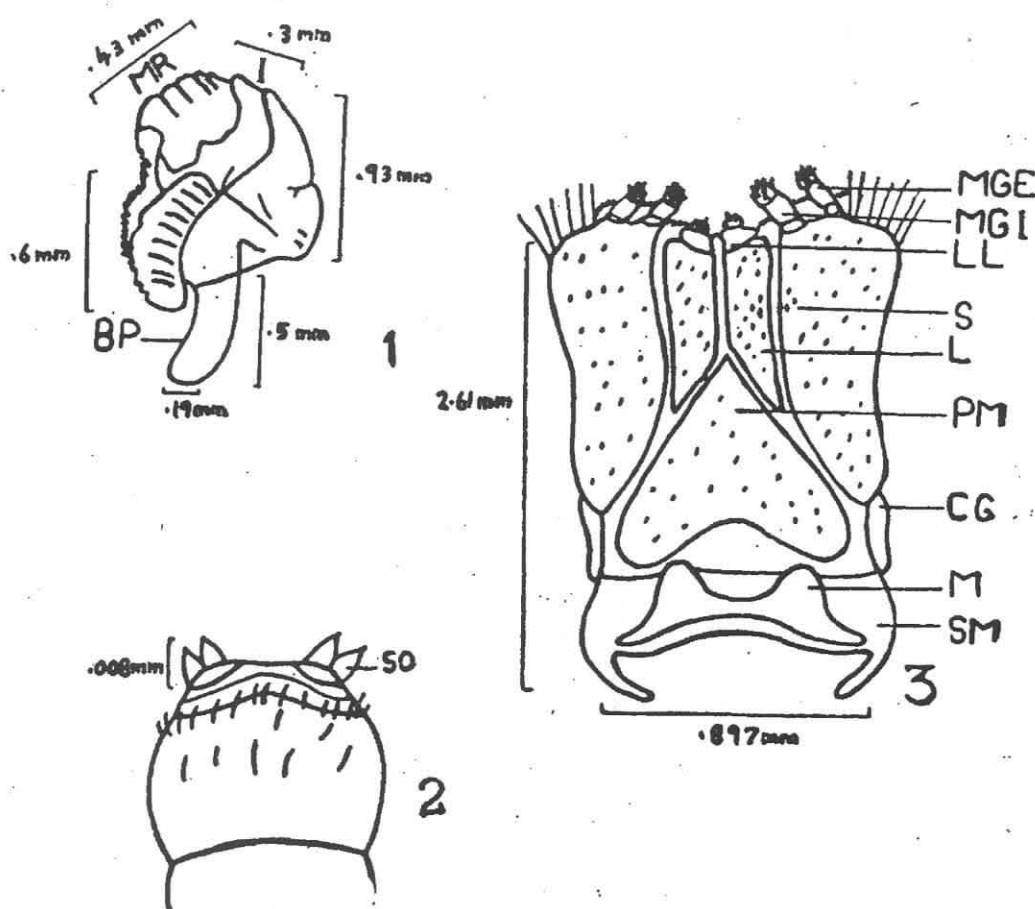
Litter types	Polyphenol content (mg% $\pm$ SEM)	Sugar content (mg% $\pm$ SEM)
<i>Artocarpus</i>	0.25 $\pm$.064	1.09 $\pm$.158
<i>Anacardium</i>	1.19 $\pm$.414	1.63 $\pm$.376
<i>Terminalia</i>	0.83 $\pm$.200	0.83 $\pm$.133
<i>Eucalyptus</i>	0.57 $\pm$.190	1.68 $\pm$.132

cases, food is preferred. According to Harborne (1980) many plant phenols are toxic when existed in free form, some may be toxic at a particular concentration and so consideration must be given to different ways that these compounds are conjugated in plant cells. In *Anacardium*, polyphenol content is high compared to sugar and so it is not preferred. In *Eucalyptus*, although sugar is found to be more than polyphenol, it is well known for its high amount of tannin and other aromatic oils, which were not estimated in the present study.

Thus preference of litter exhibited by *J. splendidus* also seems to be a balance between attractant and repellents in the food as noted by Sakwa (1974) in certain species of millipedes, *i. e.* the need for nutrients and need to avoid deterrent chemicals (Bernays & Chapman, 1978). Bano & Krishnamoorthy (1981b) also suggested that polyphenols and tannins may be the rejection factors in the food to millipedes along with several other factors unknown.

Mouth parts and feeding mechanism

Like most millipedes, *J. splendidus* also possesses a biting type of mouth.



Figs. 1-3. 1. Mandible, 2. Gnathochilarium, 3. Tip of Antenna showing sense organs. (BP=Basal portion, CG=Cardognathochilarii, I=Incisors, L=Lingua, LL=Lingual lobe, M=Mentum, MGE=Malagnathochilarium exterior, MGI=Malagnathochilarium interior, MR=Molar region, PM=Prementum, S=Stipes, SM=Submentum, SO=Sense organ).

parts. The upper lip is found to be fused with the rest of the head. Other parts include a pair of mandibles and gnathochilarium. The mandibles adapted for mastication are moved by powerful muscles. Each mandible is composed of a basal picce and a distal one bearing a large movable tooth and a masticatory plate with toothed ridges (Fig. 1). Their wide flat chewing surfaces meet in the middle. Gnathochilarium is a broad plate covering the under parts of the head (Fig. 2). It is only basally attached and possesses a number of parts marked off from one another. In the center, there is a triangular plate called prementum, bound posteriorly by the mentum and submentum. Lateral to prementum, are the stipes, one on each side. In front of the stipes and connected with its anterior margin are two palps called malagnathochilarium interior and exterior. Minute sense organs known as basiconic sensillae are present at the distal end of these palps. By the side of the stipes and lateral to the prementum lie a pair of rectangular plates, one on each side called the lingua. Each lingua has a lingual lobe. These lobes also possess one pair of sensory spines each.

Posterior to the stipes on each side is the cardo. A hypopharynx is also present. The mouth parts described here closely resemble that of other millipedes like *Spirostreptus* and *Thyropygus*.

During the course of the studies, it was observed that besides mouth parts, the first and second pair of legs and antennae also take part in the process of feeding. While moving, the animal was found touching in front and on both the sides of the substratum with the antennae (Fig. 3) since antennae and other exoskeletal outgrowths in these animals are the chief sense organs and are tactile, possibly to locate food and assess its surroundings. When there was no food in the experimental container, the exploratory behaviour to locate traces of food could be seen.

Possible reasons for food preference

Among the preferred litter, *Terminalia* is soft in nature. *Artocarpus* is having more thickness. All the three preferred litters have different texture as regards its venation. Leaf litter having low thickness and soft texture (*viz-Polyalthia*) was not preferred. Thus the mechanical features of leaf tested were found to be less significant as regard to palatability of the animal. The possible reasons for preference among different species of plants as also the different stages of decay could be due to the initial amount and the rate of changes in the chemical constituents (both phagostimulants and deterrents) in the leaf when it underwent decomposition in the soil, which in turn is influenced by certain biotic and abiotic factors.

From the above tests, it is clear that *J. splendidus* can assess the nutritive quality of its diet which in turn depends upon the presence of repellent or attractant chemicals *i. e.* it accepted litter having low content of polyphenol and high content of sugar. It is also found that the animal is not monophagous and that it

needs a variety of food stuffs in the order of preference as indicated in the Table I & II.

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